12 Policy mixes for sustainable energy transitions

The case of energy efficiency

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Introduction

Any new policy goals pertaining to sustainable energy transitions and associated policy instruments to help foster such change will not exist in a vacuum. Rather, they will become embedded in pre-existing policy contexts with legacies of goals and instruments already in place (Kern and Howlett, 2009). It is this messy reality which ultimately influences policy outcomes instead of theoretical considerations around 'first best' policy options and 'optimal' policy design. It is therefore increasingly important to explicitly study policy mixes, how they can be designed and how they can be implemented in order to promote deliberate sustainable energy transitions (Rogge *et al.*, 2017). The policy mix literature is an attempt to make sense of this empirical complexity.

This chapter therefore focuses on policy mixes for sustainable energy transitions, an emerging area of research at the interface of policy sciences and sustainability transition studies. However, definitions of what constitutes a policy mix vary widely in the literature. For example, while economists focus on the interactions of multiple instruments (Lehmann, 2012), the policy design literature goes beyond that by also including policy goals (Kern and Howlett, 2009). In addition, innovation studies have called for a reconceptualisation of policy mixes to better capture their complexity in a 'real-world' context, including the underlying policy processes through which policy mixes develop (Flanagan *et al.*, 2011, Rogge and Reichardt, 2016). Within The Centre on Innovation and Energy Demand (CIED), we have built on these various streams of literature to further conceptual and empirical insights on real-world policy mixes for sustainable energy transitions (Rogge *et al.*, 2017).[1]

Research on policy mixes started initially with an interest in multiple policy instruments targeting a given policy field (such as energy policy). In contrast to earlier proposals to address each policy goal via one policy instrument, this early literature on policy mixes – typically grounded in economics – acknowledges the existence of situations in which 'several – instead of one – policy instruments are used to address a particular environmental problem' (Braathen, 2007, p. 186). Further, '[p]olluting sources may be affected directly or indirectly by several policies addressing the same pollution problem. This is referred to as a

policy mix' (Lehmann, 2012, p. 1). The aim of this literature is mainly to understand how different instruments interact to avoid negative effects.

Accordingly, much of the early research on policy mixes for energy transitions has focused on the analysis of interactions of policy instruments designed to affect the operation of energy systems (e.g. Sorrell and Sijm, 2003; Spyridaki and Flamos, 2014). This line of thinking in terms of mixes of policy instruments has also been picked up by organisations like the International Energy Agency (IEA) which published a report on 'Interactions of Policies for Renewable Energy and Climate' (IEA, 2011a). In another publication it argued that

> [t]he need for a policy mix has been recognised by many governments, but experience to date has been that the interactions among multiple policies are often not well understood nor well-coordinated, which can lead to policy redundancy or policies undermining one another, reducing the effectiveness and efficiency of the overall package.
>
> (IEA, 2011b, p. 60)

However, definitions of policy mixes since have extended beyond instrument interactions. Consequently, there is a range of interesting strands of research on policy mixes for energy transitions (see the section below). These may combine attention to the instrument mix with corresponding policy strategies with their long-term targets, and/or with the associated policy processes; the analysis of overarching policy mix characteristics such as consistency, coherence or credibility; and policy design considerations. Such a broad perspective on policy mixes for energy transitions draws influences from multiple areas, including governance arrangements for policy mixes (e.g. Howlett and Rayner, 2006), instrument mixes in energy policy (e.g. del Río, 2010; Sorrell and Sijm, 2003) and innovation policy mixes (e.g. Flanagan *et al.*, 2011). It also connects more explicitly to the sustainability transitions literature (Markard *et al.*, 2012). The policy relevance of such a consideration of broader policy mixes is also evidenced by the interest of the IEA that published a report on 'Real-world Policy Packages for Sustainable Energy Transitions' (IEA, 2017).

While policy mix thinking is relevant generally in all policy fields, it is specifically important in the context of energy transitions. Public policy is expected to heavily contribute to sustainable change in energy systems, not only by internalising externalities but also by addressing a range of other structural and transformational system failures (Weber and Rohracher, 2012). However, energy systems are a complex web of sub-systems, including a diversity of fuel supply, conversion and use systems, which are often addressed by a range of different policies – making the overall policy mixes large, complicated and most likely incoherent.

Much of the emerging research on policy mixes for energy transitions has, however, focused on energy supply, while there is much less research on energy efficiency policy mixes. This is so despite the fact that energy efficiency is considered as critically important to achieving an energy transition in line with the pledges made in the Paris Agreement (IEA, 2015) (see Chapter 1 and

Chapter 2). In addition, the respective policy literature has often pointed out that due to the variety and complexity of end-users of energy, there are no 'silver bullet' policies that can stimulate action across this variety of actors. Instead of single instruments, it has been argued that there is a need to design comprehensive energy efficiency policy mixes which address the various challenges different actors are facing in advancing energy efficiency (Nilsson, 2012). This is reflected in policy strategies aimed at influencing energy efficiency but is not studied much in the existing energy efficiency policy literature.

This constitutes the main empirical gap in the literature that our research was trying to address. The aim of this chapter is to summarise some of the empirical research on energy efficiency policy mixes conducted as part of CIED in order to draw out overall academic insights and avenues for further research. We also provide policy reflections on policy mixes for sustainable energy transitions in which energy efficiency plays a key role. The next section introduces recent conceptual and empirical advances in the interdisciplinary literature on policy mixes for energy transitions. The following section discusses selected research on energy efficiency policy mixes in the UK, Finland and at the EU level conducted by CIED. The final section summarises what overall lessons we have learned from this work, develops policy recommendations and suggests a number of avenues for future research.

Advancing research on policy mixes for energy transitions

Given the rapid increase in interest in the topic of policy mixes for energy transition two CIED authors (jointly with Michael Howlett) guest-edited a recent special issue in the journal of *Energy Research and Social Science* (November 2017, Vol. 33)[2] which goes beyond looking at instrument mixes. As summarised in Rogge *et al*. (2017) the contributions in this special issue are clustered around five themes: policy mix rationales, interactions and coordination of policy instruments, designing effective policy mixes, policy mixes for creative destruction and the role of actors and institutions in shaping energy transition policy mixes. Below we will discuss a number of selected contributions to the special issue in order to illustrate these different strands of work.

In terms of *policy mix rationales*, Jacobsson *et al*. (2017) argue that European Union (EU) interventions in the context of decarbonisation mainly rest on neoclassical economics assumptions. They propose that this approach neglects important insights about the non-linear nature of technical change and industrial dynamics that are very relevant in the context of energy transitions. They propose an innovation system approach as a rationale for intervention and draw lessons for how effective instrument mixes can be designed which pay greater attention to dynamic efficiency and the structural build-up of innovation systems.

Contributing to the theme of *instrument interactions*, del Río and Cerdá (2017) analyse the impact of instruments to promote renewable electricity on CO_2 prices established through a cap and trade scheme or carbon tax. Their research shows that negative interactions can be mitigated through coordination, and that the

adaptability depends on the choice of instruments and design features of each tool. They also find that the negative impact on CO_2 prices is more likely under quantity-based than under-price-based instruments.

In terms of *designing effective policy mixes*, Falcone *et al.* (2017) provide an analysis of policy mixes in the Italian biofuel sector. They explore different crises scenarios in order to identify and recommend the most effective policy combinations to foster a sustainable energy transition using a fuzzy inference. Their findings show that the most effective policy mixes vary across the scenarios and according to different pursued objectives.

Under the theme of *policy mixes for creative destruction*, Rogge and Johnstone (2017) analyse the effect of deliberate phase-out policies of established technological regimes on the development and diffusion of low-carbon technologies. Based on the case of the German transition towards renewable electricity, they show through a survey of innovation activities of German manufacturers of renewable power generation technologies that Germany's nuclear phase-out policy had a positive influence on manufacturers' innovation expenditures for renewables.

In terms of the *role of actors and institutions in shaping energy transition policy mixes*, Bahn-Walkowiak and Wilts (2017) undertake a closer analysis of the institutional background of policy mixes. Their contribution raises questions about the potential impact of different institutional settings on the consistency and coherence of policy mixes in the field of resource efficiency. They map the distribution of institutional responsibilities in 32 EU countries and find that resource efficiency policies are still mainly disconnected from energy issues. The paper stresses the need to include institutional and multi-level governance considerations into the design and development of policy mixes.

These five themes are showcasing the variety of strands of research on policy mixes for energy transitions but empirically much of this research has focused on energy supply policy mixes. However, little work within these themes focuses specifically on energy efficiency.

Applying policy mix thinking to the case of energy efficiency: what have we learned?

Having reviewed recent research on policy mixes for sustainable energy transitions and identifying some key themes, this section will summarise selected empirical analyses of energy efficiency policy mixes which have been conducted as part of CIED and which contribute to discussions in a number of these strands.

How do complex policy mixes develop over time and how consistent and coherent can they be? The cases of UK and Finnish energy efficiency evolution

Much of the existing energy policy mix literature only captures the policy mix at one point in time. We argue that in the context of long-term energy transitions, further analysis is needed to investigate how real-world policy mixes

develop over time and how their characteristics change. In line with existing literature in the field of policy design, we claim that this is important as it influences the potential performance of such complex mixes.

In Kern *et al.* (2017) we therefore adopted the definition of policy mixes as 'complex arrangements of multiple goals and means which, in many cases, have developed incrementally over many years' (Kern and Howlett, 2009, p. 395). Conceptually, we drew on the work of Howlett and colleagues who have foregrounded two relevant characteristics of policy mixes: consistency and coherence. Howlett and Rayner (2013) define consistency as 'the ability of multiple policy tools to reinforce rather than undermine each other in the pursuit of policy goals' (p. 174). They define coherence as the 'ability of multiple policy goals to co-exist with each other and with instrument norms in a logical fashion' (ibid.).

However, such characteristics of mixes are never static since goals and instruments may be added to and subtracted from the mix over time. Existing research has distinguished four processes through which policy mixes typically change: *layering*, *drift*, *conversion* and *replacement* (Howlett and Rayner, 2007, 2013; Kern and Howlett, 2009; Table 12.1).

Layering refers to adding new policy goals and instruments to the mix without discarding previous ones (Howlett and Rayner, 2013). Howlett and Rayner (2007) argue that this often results in incoherence among goals and inconsistency of instruments. *Drift* refers to changing policy goals without 'changing the instruments used to implement them. These instruments then can become inconsistent with the new goals and most likely ineffective in achieving them' (Kern and Howlett, 2009, p. 395). *Conversion* involves the reverse situation in which instrument mixes evolve while the old goals are retained: 'If the old goals lack coherence, then changes in policy instruments may either reduce levels of implementation conflicts or enhance them, but are unlikely to succeed in matching means and ends of policy' (ibid.). *Replacement* refers to a process in which a conscious effort is made by policymakers to fundamentally restructure

Table 12.1 Relationship between policy development processes and the expected coherence and consistency of a policy mix

Instruments goals	*Consistent*	*Inconsistent*
Coherent	*Replacement:* conscious effort to restructure goals and instruments by sweeping aside the old mix and designing a new one from scratch	*Conversion:* instruments evolve while the old goals are retained
Incoherent	*Drift:* changing policy goals without changing the instruments used to implement them	*Layering:* adding new policy goals and instruments to the mix without discarding previous ones

Source: based on Kern and Howlett (2009, p. 396).

both goals and instruments in a coherent and consistent manner by sweeping aside the old mix and designing a new one from scratch (Howlett and Rayner, 2007). However, most policy mixes develop through either *layering, conversion* or *drift*, often resulting in inconsistent and incoherent policy mixes (Howlett and Rayner, 2013).

We applied this framework to the development of building energy efficiency policy in Finland and the UK between 2000–2014. The analysis was based on a systematic review of existing databases,[3] policy documents and IEA country reviews to identify current building-related policy goals and instruments at the national level, as well as identifying goals and instruments, which had been added, amended and removed during this timeframe. This information allowed us to trace policy developments over time. We utilised 19 stakeholder interviews to check the list of policy instruments and elicit information about the development of the policy mixes (including insights related to their coherence and consistency).

In the case of Finland, the development of the policy mix tended to follow a *replacement* process in the form of coherent long-term policy goals and (increasing) consistency of the instrument mix used to implement them. These processes have led to a policy mix with some promise of effectiveness. In contrast, the UK analysis revealed a pattern more akin to *drift* as the introduction of social and carbon reduction goals into traditional energy efficiency ambitions led to a set of partly incoherent goals. The goals are combined with a relatively consistent and prior to 2015 largely well-targeted instrument mix but which also displayed some gaps. The case also showed a rapid accumulation of new instruments (*layering*).

Overall, the analysis showed that both countries have developed extensive policy mixes to address building energy efficiency, including a variety of goals and instruments and making use of many different instrument types. In both countries, more new goals and instruments have been added over time than have been, which poses increasing challenges in terms of policy coordination as well as evaluating such increasingly complex mixes. Our analysis also showed that while in the UK there has been a lot of 'churn' in policy instruments, Finland has had a somewhat more stable policy mix, where the added policies have not as radically altered the mix. This is important in the context of policy mixes for energy transitions as a rapidly fluctuating policy environment can slow down innovation processes, as companies generally prefer a more stable climate for investment. This means that the UK policy mix may deter low-energy innovations and their diffusion.

What kinds of comprehensive and well-targeted instrument mixes are needed for stimulating energy efficiency improvements?

The comprehensiveness of policies has long been argued to be a relevant success factor of environmental and energy policies (Sovacool, 2009; Walls and Palmer, 2001). However, in these studies, comprehensiveness has remained a loosely

defined concept. Drawing on conceptualisations of comprehensiveness in the field of marketing and environmental management systems (Atuahene-Gima and Murray, 2004; Miller, 2008), Rogge and Reichardt (2016) have concretised policy mix comprehensiveness as a characteristic which 'captures how extensive and exhaustive its elements are' (p. 1627). While they also include the degree to which policymaking and implementation are based on extensive decision-making, in this paper (Rosenow *et al.*, 2017), we focused on the comprehensiveness of the instrument mix in the area of energy efficiency in selected EU Member States.

In line with Rogge and Reichardt (2016) we argue that instrument mix comprehensiveness can be assessed according to the degree to which it considers relevant failures and barriers (Lehmann, 2012; Sorrell, 2004; Weber and Rohracher, 2012). More specifically, it can be captured by assessing whether the instrument mix includes technology push, demand pull and systemic instruments (Cantner *et al.*, 2016). We developed an analytical framework that can be used for the empirical assessment of energy efficiency instrument mixes and their degree of comprehensiveness (Rosenow *et al.*, 2017). The main building blocks of the framework we applied in this chapter are (a) technological specificity, (b) types of policy instruments and (c) sector specificity.

Technological specificity can be assessed using two dimensions: the cost of supported technology and the complexity of supported technology. Instrument types are critical for comprehensiveness as there is great variety of policy instrument types. Depending on the type, policy instruments also support specific technologies or are technologically neutral. A sector specific analysis may reveal important gaps in the instrument mix. This is important since the ambitious energy efficiency targets required for sustainable energy transitions mean that all sectors have a significant contribution to make (Braungardt *et al.*, 2014). While comprehensiveness may also be assessed through the lens of additional dimensions (for example the degree to which all relevant actors are addressed or the degree of geographical coverage etc.), we argue that our analytical framework covering three key aspects offers an approach that can be applied relatively easily to existing instrument mixes within the energy efficiency policy domain.

We applied this concept of instrument mix comprehensiveness to the field of energy efficiency. The empirical analysis focuses on national energy efficiency policies that have been notified by EU Member States to the European Commission as part of their transposition of Article 7 of the EU Energy Efficiency Directive (EED). The EED establishes a framework of measures to ensure the achievement of the EU's 20 per cent energy savings target by 2020 (EU, 2012). Data on instrument mixes in selected EU Member States was obtained from national experts from Austria, Belgium, Bulgaria, Denmark, Estonia, France, Germany, Greece, Italy, Netherlands, Poland, Spain, Sweden and the United Kingdom.[4]

The data shows that in the selected EU Member States none of the instrument types utilised by these countries specifically target highly complex and capital-intensive technologies, but instead focus on technologies characterised

by relatively moderate costs and complexity. We argue that a comprehensive energy efficiency instrument mix needs to cover the full range of technologies regarding complexity and costs. The limited focus on more complex and costly technologies indicates that further policy development is required in order to achieve deeper energy efficiency improvements across all sectors.

This finding may partly be a function of the focus on existing commercialised technologies (rather than innovative technologies or technology combinations) that characterises Article 7 policies. However, it also indicates a possible gap in the instrument mix supporting deeper energy efficiency improvements, whereby the next set of mass market efficiency measures are not being sufficiently supported or incentivised. This gap needs to be addressed if ambitious EU targets are to be met. However, adding such instruments may be costly and, therefore, politically contested.

Future research should identify more precisely (through ex post analyses) the degree of comprehensiveness of the instrument mix. In particular, one focus of such studies should be the types of technologies targeted within the energy efficiency space as this becomes increasingly important given the diversity of national approaches to delivering EU energy-savings targets.

Accelerating sustainable energy transitions by fostering creative destruction through policy mixes?

When major transformations of energy systems are needed, particularly at a rapid pace, it is not sufficient that a policy mix aims at incremental improvement and innovation support. In such cases, the policy mix also needs to entail more disruptive instruments to overturn unsustainable energy regimes based on fossil fuels and high levels of energy consumption. What elements such policy mixes should comprise, was the focus of a study published by Kivimaa and Kern (2016) that this sub-section is based on. Empirically, it analysed whether contemporary policy mixes for low-energy innovation in the UK and Finland have the characteristics proposed.

The core idea proposed in the study is that well-designed policy mixes for sustainable energy transitions would include elements of 'creative destruction', involving both policies aiming for the 'creation' of new and for 'destabilising' the old. However, creating such policy mixes is by no means easy as it is dependent on the prevailing political climate (Howlett and Rayner, 2007). Yet, we argue that energy transitions benefit from analyses of the degree to which this takes place, and how existing policy mixes could be improved in this regard.

The framework developed in Kivimaa and Kern (2016) proposes to conceptualise policy mixes from the perspective of creative destruction. It draws on multiple innovation and transition concepts, including disruptive innovation (Abernathy and Clark, 1985; Christensen, 1997), technological innovation systems (Bergek *et al.*, 2008; Jacobsson and Bergek, 2011; Suurs and Hekkert, 2009), Strategic Niche Management (Hoogma *et al.*, 2002; Smith and Raven, 2012) and transition management (Kemp and Rotmans, 2004; Rotmans *et al.*,

2001). Drawing from technological innovation systems and Strategic Niche Management literatures, it is clear that to support the emergence of new innovative niches, policy mixes need to address the following functions:

1 knowledge creation, development and diffusion (e.g. R&D funding schemes, innovation platforms, educational policies);
2 new market formation (e.g. regulation, economic policy instruments, public procurement);
3 price–performance improvements (e.g. deployment and demonstration subsidies enabling learning-by-doing);
4 entrepreneurial experimentation (e.g. policies stimulating entrepreneurship and diversification of existing firms);
5 resource mobilisation (e.g. R&D funding subsidies, low-interest loans, labour-market policies);
6 support from powerful groups/legitimisation (e.g. foresight exercises, labelling); and
7 influence on the direction of search (e.g. strategic goals, targeted R&D funding, regulations, tax incentives, voluntary agreements).

In addition, Kivimaa and Kern (2016) argue, with support from the literature on transitions management and disruptive innovation, that in cases of unsustainable energy regimes, policy mixes also need to address the following regime destabilising functions:

1 control policies that internalise environmental costs (e.g. pollution taxes, carbon trading);
2 significant changes in regime rules (e.g. structural reforms in legislation or significant new overarching legislation);
3 reduced support for dominant regime technologies (e.g. withdrawing support for unsustainable technologies by cutting/removing R&D funding and other subsidies, or technology bans); and
4 changes in social networks and replacement of key actors (e.g. increasing the number of niche actors in advisory councils and forming new organisations and networks with key roles in system change).

Empirically, we examined the policy mixes in Finland and the UK addressing energy efficiency and energy demand reduction. The analysis covered three regimes – mobility, electricity and heating of buildings – cutting across multiple policy domains including innovation, energy, fiscal and transport policies. The method utilised was a policy instrument mapping exercise systematically going through four international data sources: the IEA's reviews of energy policies and policies and measures databases on energy efficiency, the European Environmental Agency's database on climate change mitigation policies and measures, the European Commission's Erawatch research and innovation policy database and the IEA Sustainable Buildings Centre's Building Energy Efficiency Policies

database. In addition, the data was supplemented with searches made on governmental websites to get descriptions of the objectives, justifications and main content of the policy instruments, and to identify new organisations and networks.

The study identified 73 policy instruments in the UK and 65 in Finland. In both countries there was an imbalance of policy instruments between niche support and regime destabilisation, although several 'control policies' were found in both countries. This imbalance was not only reflected in the number of instruments but also in policy content. Specifically, significant changes in regime rules and in policy networks and actors were rare. In addition, in the UK, we did not find reducing policy support for high-energy technologies beyond EU requirements. This is not surprising given the political difficulties of such changes but highlights gaps in the existing policy mixes.

Some of the destabilising functions proposed here connect to a recent and emerging debate on exnovation policies that aim to end use of given technologies by deliberately removing the infrastructure it relies on (David, 2017). In addition, our study links to the debate on the need for explicit phase-out policies to support sustainable energy transitions (Rehner and McCauley, 2016; Rogge and Johnstone, 2017). Further research could examine the development of 'creative destructive' policy mixes over time, how the instruments function in practice and their impact on the strategies of different policy target groups.

How to expand policy mix studies to the analysis of policy processes?

As mentioned above, recent research on policy mixes for energy and sustainability transitions has developed a broader perspective on policy mixes which includes policy strategies, policy mix characteristics (such as consistency and credibility), and increased attention to actors and institutions (Rogge *et al.*, 2017). One of the additional aspects highlighted as particularly worthy of further consideration within broader policy mix research are policy processes and the role they play for advancing sociotechnical transitions towards sustainability (Flanagan *et al.*, 2011; Rogge and Reichardt, 2016). Research shedding greater light on the process dimension of policy mixes calls for extending the interdisciplinary nature of policy mix research by more explicitly incorporating theories of the policy process (Sabatier and Weible, 2014).

As argued in Kern and Rogge (2018), such a greater attention to policy processes promises three advantages. First, policy processes can have direct impacts on innovation rather than just an indirect impact by shaping policy strategies and instrument mixes (Reichardt *et al.*, 2017). Second, studying the co-evolution of policy and sociotechnical change calls for more explicit attention to policy processes, which in turn may enable a better understanding of the dynamic nature and causal links between the two (Hoppmann *et al.*, 2014; Reichardt *et al.*, 2016). Third, a more sophisticated conceptualisation of policy processes may allow for a more proactive consideration of the underlying politics when drafting policy advice regarding policy design and procedural aspects

and may thus have a greater chance of being adopted (Edmondson *et al.*, 2018; Rogge and Reichardt, 2016).

Only few studies in the field of sustainability transitions have so far substantively drawn on theories of the policy process (Kern and Rogge, 2018). Exemptions include Markard *et al.* (2016) drawing on Sabatier's advocacy coalition framework (ACF) (Sabatier, 1988), Geels and Penna (2015) drawing on Baumgartner's punctuated equilibrium theory (Baumgartner and Jones, 1993) as well as Normann (2015) drawing on Kingdon's multiple streams approach (Kingdon, 1995). However, most of these contributions rather loosely build on theories of the policy process and typically refrain from justifying their choice vis a vis alternatives. In addition, they often rely on the 'classic' version of these analytical frameworks, neglecting more recent debates and further conceptual developments in the policy sciences literatures.

Therefore, in Kern and Rogge (2018) we provide a critical review of five well-established theories of the policy process. These include Sabatier's ACF, Kingdon's multiple streams approach, Baumgartner's punctuated equilibrium theory, Hajer's discourse coalitions framework (Hajer, 1995), and Pierson's policy feedback approach (Pierson, 1993). For each of these theories we provide an overview of the origin, key concepts, empirical applications, recent theoretical advances and most important criticisms (see Table 12.2). Perhaps most importantly we also offer reflections on their suitability for answering research questions of interest to scholars in the field of sociotechnical transitions towards sustainability. Overall, we find a great potential for cross-fertilisation of ideas across transition and policy studies, but we also identify two important shortcomings.

The first shortcoming is that these theories are often applied to study the emergence of single policy instruments or purposively designed policy programmes, rather than to explain the evolution of messy, real-world policy mixes. However, as such policy mixes are particularly important in the context of energy transitions, we argued that the reviewed theories of the policy process may have to be adapted to the logic of thinking in terms of policy mixes. For example, greater attention should be paid to policy changes which guide the direction of change, e.g. towards low-carbon solutions (Kern and Rogge, 2016).

The second shortcoming is that analyses often stop short at the output of policy processes and do not study policy outcomes and impacts, which are of particular importance in studying sustainable energy transitions. Indeed, many of the reviewed theories only help to explain how and why policies were adopted, with little attention to how these policy outputs impact the sociotechnical system. In Kern and Rogge (2018) we differentiated between direct and indirect links between policy processes and sociotechnical change which both should be taken into consideration in future policy mix studies. While the indirect link manifests itself through policy outputs (e.g. changes to the instrument mix) leading to impacts on the sociotechnical system, the direct link suggest that the nature of policy processes, such as a participatory policymaking style, can also directly influence sociotechnical change, e.g. through influencing perceptions and beliefs of innovators (Reichardt *et al.*, 2017).

Table 12.2 Overview of policy process theories and their application in transition studies

	Advocacy coalition framework	*Multiple stream approach*	*Punctuated equilibrium theory*	*Discourse coalition framework*	*Policy feedback theory*
Scope and level of analysis	Advocacy coalition interaction, learning and policy change Coalitions and subsystems	Policy choice under ambiguity System, but implicit, and focus is on actors coupling streams	Political system towards stability and periodic major change System	Discourse coalition interaction, discursive struggles Coalitions and subsystem	How policies shape politics and subsequent policymaking System, but implicit
Model of the individual	Bounded rational; emphasis that individuals are motivated by beliefs and prone to devil shift	Challenges assumptions of comprehensive rationality; focus on ambiguity	Boundedly rational, particularly related to attention	Not explicitly discussed	Not explicitly discussed; suggests individual choice is shaped by policies and institutions
Actors making choices	Policy actors who form coalitions, act strategically, learn and so forth	Policy entrepreneurs and policymakers	Broadly, interest groups and other organisations, as well as individuals within groups and different venues	Policy actors who form coalitions and engage in a set of practices	Implicity, actors who are affected by policy may in turn become policy actors
Relationship among key concepts	Factors that influence coalition formation, policy learning, and policy change	Broadly, three streams that come together during 'windows of opportunity' to cause major policy change	Factors that lead to major policy change and those that constrain change or produce incrementalism	Discourses are reproduced through practices and influence the policy response to policy problems as well as whether certain situations are seen as public policy problems	The effects of public policy on the meaning of citizenship, form of governance, power of groups, and political agendas – all of which affect future policy

Most promising aspects from transition studies perspective	Reconceptualise policy regime, incl. competing advocacy coalition(s) and integrate how beliefs can change over time and with what effects on dominant advocacy coalition Incorporate role of public opinion on policymaking	Focus on policy entrepreneurs sheds light on role of individual agency vis-à-vis systems Idea that solutions/ policies look for problems is useful in studying agency of niche actors pushing their respective solutions, but also requires detailed analysis of developments in politics stream	Clear parallels in conceptualising equilibrium and path dependency which can be disrupted by crises in both punctuated equilibrium theory (PET) and multi-level perspective (MLP): scope for mutual learning about mechanisms of change Approach can be also applied to diffusion of public policy innovations which is useful in the context of technological innovation system (TIS) studies trying to account for transnational factors and institutional political contexts	Focus on interpretative processes and the roles of ideas in shaping policy, especially in situations of Knightian uncertainty, is very promising Foregrounding discursive struggles between competing discourse coalitions is a useful conceptual tool to focus on the politics of transition processes (e.g. on how actors interpret sustainability and the goals of potential transitions differently)	Promising approach to conceptualise the co-evolution between policy mixes and sociotechnical systems (via policy effects and feedback processes) Extend notion of path dependency of policy regime by paying attention to various policy effects as well as feedbacks Utilise approach to conduct analyses of effects of policies on mass publics and their political mobilisation in transitions
Application in transitions literature	Markard *et al.* 2016; Geels and Penna 2015	Normann 2015; Elzen *et al.* 2011	Geels and Penna 2015	Smith and Kern 2009; Rosenbloom *et al.* 2016	Edmondson *et al.* 2018

Source: Kern and Rogge (2018), with permission.

Within CIED we have started to tackle both shortcomings by developing an interdisciplinary conceptual framework for investigating the co-evolution of policy mix and sociotechnical change (Edmondson *et al.*, 2018). In order to explicitly consider the role of policy processes in this co-evolutionary process we have drawn on Policy Feedback Theory, which focuses on how policies shape politics and the resulting effects on further policymaking. Integrating this theory of the policy process with sociotechnical transitions thinking allows us to account for multiple policy effects (resource, interpretative and institutional) on sociotechnical change and resultant feedback mechanisms (cognitive, administrative and fiscal) influencing the policy processes that underpin further policy mix change.

We have illustrated this novel analytical framework using the case of the UK zero carbon homes policy mix. This is an example where an ambitious policy target lost political support over time due to a range of policy effects and feedback mechanisms, ultimately leading to its abandonment. The example highlights that policy mixes for sustainable energy transitions should be designed to create incentives for beneficiaries to mobilise further support, while at the same time addressing a number of prevailing challenges that may undermine political support over time. Overall, we think that drawing on a range of policy process theories can enrich academic analysis and provide more adequate policy thinking about policy mixes for energy transitions.

Conclusions and policy recommendations

The research summarised in this chapter aptly demonstrates that policy mix thinking is an important analytical perspective in the context of policies to support sustainable energy transitions. This is because various policy mix conceptualisations allow scholars and policy analysts to better deal with the complexity of real-world policymaking rather than simplistic economic theoretical thinking about policy that still dominates scholarly and policy debates to some extent.

While instrument interactions matter and have been the subject of much research, this chapter has argued that there are important other issues to consider. Such issues include different policy mix rationales, processes of designing and maintaining effective policy mixes over time, the need to deliberately phase out unsustainable technologies and practices, and the important role of actors and institutions in influencing the design and implementation of policy mixes. The research summarised above provides important early insights into these issues.

Research implications

Our research identified a variety of avenues for future investigations. Given the complexity of studying policy mixes (the larger the mix analysed, the less depth and complexity can be addressed), there is only relatively little research that takes a comparative perspective. However, as our CIED research discussed above shows, comparative analysis can lead to interesting insights. It can highlight issues in a policy mix that only reveal themselves in comparison to another

policy mix (in a different country or sector, for example). Such comparative work could help explain key similarities and differences, thereby potentially identifying generic (e.g. technology or sector-related factors) as well as country specific factors (e.g. national policy traditions or policy styles) (e.g. see Howlett and Ramesh, 1993).

There are also open questions about which institutional arrangements can foster the development of well-coordinated and comprehensive policy mixes and which capabilities are required for managing complex policy mixes. Few if any studies focus on how policymakers and implementing organisations can acquire or develop such competences. This development of competences is especially difficult in administrative contexts, where civil servants' work is focused on developing one specific new policy instrument in isolation and who often remain in a department only for a short time, as is the case in the UK.

In addition, the evaluation of real-world (rather than intended) policy mixes for transitions has been little addressed (Kivimaa *et al.*, 2017). There are important questions about how to evaluate the impact of such policy mixes ex post and *ex ante*. While much research focuses on characteristics of policy mixes such as coherence or consistency as a proxy for potential success, more sophisticated methodologies are needed to analyse potential or actual effects of complex policy mixes on energy transitions. One possibility to make progress in this regard is to draw on the evaluation literature and adopt their approaches to policy mix analysis as has been proposed by Kivimaa *et al.* (2017).

One further avenue for future research is to explore how to phase policies and alter policy mixes in line with progress of energy transitions. This is an issue raised recently e.g. in Meckling *et al.* (2017) but there is not much explicit consideration of these issues in the sustainability transitions literature yet. Future research should therefore combine policy mix thinking with the work on different phases of transitions and work out which combinations of instruments are most appropriate for which phase.

Finally, future research should pay greater attention to the politics of designing policy mixes. While Rogge and Reichardt (2016) include policy processes in their framework for studying policy mixes, there is little detail on how the politics of such processes might be conceptualised. As summarised above we conducted a review of different policy process theories and their potential use in the context of studying the politics of sustainability transitions (Kern and Rogge, 2018) and have developed a novel framework based on the policy feedback literature (Edmondson *et al.*, 2018) but much research remains to be done on this important aspect of policy mixes.

Policy recommendations

Given the broad scope of the research reported in this chapter and the varied empirical cases which our research has covered, the idea here is to draw out some broad principles for policymaking rather than providing suggestions about specific interventions or policy changes.

In line with existing work on energy efficiency policy our research on energy efficiency policy mixes strengthens the notion that there are no 'silver bullets', i.e. single instruments that can bring about energy transitions. Instead policymakers need to develop well-managed portfolios of policy goals, strategies and instruments to foster energy transitions. These policy mixes need to be continuously (re-)assessed and modified as necessary when the transition progresses and may need to be backed up with supportive changes in administrative organisations and processes.

In terms of supporting energy efficiency and energy demand reduction as a core contribution to sustainable energy transitions, it has been argued that 'efficiency first' should be a primary policy goal (Rosenow and Cowart, 2017). For policymakers this principle means that, put simply, the policy mix should prioritise incentivising investments in customer-side efficiency (including end-use energy efficiency and demand response) whenever they would cost less, or deliver more value, than investing in energy infrastructure, fuels, and supply alone. While this may sound very much like common-sense policy, unfortunately this principle is not heeded in much energy policy. For example, in the UK not a single pound of the £256 billion investment pipeline for energy infrastructure is allocated to energy efficiency improvements (Rosenow and Cowart, 2017).

Beyond such broad principles informing policy mix design, there is 'no one size fits all', ideal instrument mix, but policy mixes need to be tailored to specific goals and the (institutional and country) settings they are applied in. What is important is that this tailoring sufficiently acknowledges the existing policy mix, on top of which new policies are designed. This may require the phase out of existing policies supporting unsustainable energy production or consumption, while creating or maintaining sufficient support for innovation (Kivimaa and Kern, 2016). We have also emphasised the need for comprehensive instrument mixes, which in the case of aiming for radical energy efficiency improvements, for example, means not just to focus on near-term, relatively cost-effective technologies, but also requires incentives for costlier, more complex technologies which are needed for deep energy efficiency improvements (Rosenow *et al.*, 2017).

Much of the emphasis on the coherence and consistency of policy mixes in the literature may suggest that in order to develop successful mixes, policymakers need to aim for a complete overhaul of existing policy arrangements or completely new policy packages. However, Howlett and Rayner argue that policy patching can also be a successful strategy, 'much in the same way as software designers issue "patches" for their operating systems and programmes in order to correct flaws or allow them to adapt to changing circumstances' (Howlett and Rayner, 2013, p. 177). Our empirical research on Finnish energy efficiency policy shows that a patching strategy can be successful so it is important for policymakers to know that developing promising policy mixes does not require 'starting from a clean slate' (Kern *et al.*, 2017). This is a promising insight for policymakers and should encourage an honest assessment of current policy mixes for energy transitions along the lines discussed above, which can then be used to inform suitable patching strategies.

Notes

1 Various other terms such as policy portfolios, policy bundles or policy packages have been used in similar ways (see Howlett *et al.*, 2015). However, we prefer to use the notion of policy mixes as these other terms often have a connotation of deliberate and well-designed policy mixes, which does not characterise most policy mixes in reality.
2 See www.sciencedirect.com/journal/energy-research-and-social-science/vol/33.
3 These included: IEA policies and measures databases on energy efficiency, the European Environmental Agency's database on climate change mitigation policies and measures in Europe; the IEA Sustainable Buildings Centre's Building Energy Efficiency Policies database and the ODYSSEE–MURE database.
4 All of the experts were part of the Energy Saving Policies and Energy Efficiency Obligation Schemes (ENSPOL) project, which was funded by the European Commission. The full list of involved institutions can be found on the ENSPOL project website (http://enspol.eu).

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